U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Guidance Enhancement to Address Lessons Learned in Review of Civil Structures for New Reactors

Jim Xu, Ph. D
U.S. Nuclear Regulatory Commission
2013 NRC Regulatory Information Conference
March 12 - 14, 2013

U.S.NRC

Outline

- Overview
- Development process/path forward
- Technical issues addressed in proposed SRP enhancements
- Examples of how issues are addressed
- Conclusions

U.S.NRC

Overview

- SRP 3.7, 3.8 provide acceptance criteria for seismic analysis, design of containment and other Category I structures and foundations
- Last major revision to SRP completed in 2007
  - completed review of 2 DC applications and a number of COL applications
  - Continue review of other DC and COL applications on docket
  - Encountered areas where review could be made more effective and efficient
  - Identified needs for additional guidance enhancements

Development Process/Path Forward

- Team effort with staff from NRO, NRR, RES and MNSS
- Identified 11 technical issues, developed rationale and technical basis
- Proposed enhanced SRP acceptance criteria for identified technical issues
- Issued FRN for public comments (February 2013)
- Engage industry and stakeholders
  - DCWG meeting (October 24, 2012)
  - Public Workshop planned for April 2013
- Address public comments
- Plan to complete SRP 3.7/3.8 revision by Summer 2013

4

Identified Technical Issues

1. Seismic uplift in SSI analysis
2. Seismic stability evaluation for design of structures
3. Interaction of non-Category I structures with Category I SSCs
4. Seismic soil pressure on embedded walls
5. Ground motion incoherency effects on seismic SSI
6. Cracking effects on seismic analysis of concrete structures
7. Differential settlement and construction sequence considerations in foundation design
8. Artificial time history development
9. Considerations for seismic design basis
10. Issues with SASSI subtraction method
11. Guidance for assessing spent fuel pool racks and fuel assemblies

5

Example 1
Issue #1: Seismic Uplift in SSI Analysis

- **Current SRP 3.7.2**
  a. Provides qualitative guidance - sensitivity studies for separation and sliding of soil from sidewalls
  b. Does not provide uplift criteria
- **Challenge - Uplift criteria needed to ensure:**
  a. Adequacy of linear SSI analysis
  b. Adequate design - ISRS, design forces, soil pressures
- **Proposed Enhancement**
  a. Calculate ground contact ratio
  b. Acceptance criterion - greater than or equal to 80%
- **Technical Basis**
  a. JEAC 4601-2008 uses 75% criterion
  b. Proposed criteria consistent with other studies (Wolf, 1976 and NUREG/CR-4588)

6

Example 2
Issue #3: Seismic II/I Interaction

- **Current SRP 3.7.2.8**
  a. Criterion C states "The non-Category I structure will be analyzed and designed to prevent its failure under SSE conditions, such that the margin of safety is equivalent to that of Category I structures."
- **Challenges**
  a. Confusion about how to satisfy SRP 3.7.2.8 Criterion C, demonstrating no physical interaction
  b. Need to clarify that Category I design/analysis methods are NOT the only way to satisfy Criterion C
- **Proposed Enhancement**
  a. Delete "… such that the margin of safety is equivalent to that of Category I structures." May be unnecessary for large gaps, needed for small gaps
  b. Define new acceptance criterion based on NO IMPACT of non-Cat. I structures on Cat. I SSCs
  c. Inelastic analysis acceptable, if sufficient gaps exist
  d. Methods evaluated on case-by-case basis, due to numerous possibilities
- **Technical Basis**
  a. Emphasize the "no impact" aspect of criterion
  b. Analysis method selected will ensure no impact of non-Cat.1 structure to Cat I SSCs
  c. Applicant needs to consider gap tolerances at design stage

7

Example 3
Issue #4: Seismic Soil Pressure on Embedded Walls

- **Current SRP 3.8.4 identifies two methods to be considered**
  a. Sum of static plus dynamic pressure per ASCE 4-98, Section 3.5.3.2
  b. Passive pressure
- **Challenge**
  a. Seismic soil pressures can vary substantially depending on many factors
  b. Uncertainties exist in soil pressure calculations
- **Proposed Enhancement**
  a. Design is based on governing pressure from three methods, added method based on SSI analysis
  b. Clarifies fraction of passive pressure that is effectively mobilized depends on wall displacements (at a minimum, passive pressure assumed in stability calc.)
  c. Identifies limitations of Wood's elastic solution (ASCE 4-98)
  d. Emphasis on review of analysis assumptions
  e. SSSI and groundwater effects to be added if important

8

Example 3 (cont.)
Issue #4: Seismic Soil Pressure on Embedded Walls

- **Technical Basis**
  a. Seismic soil pressures complex, sensitive to many factors (kinematic configuration, passive vs. active, magnitude of soil stress/strain, granular vs. cohesive soils, groundwater, compaction, etc.)
  b. Embedded walls fundamentally different from unrestrained retaining walls ("non-yielding" vs. "yielding" walls")
  c. Field measurements and experimental investigations confirm wide variation in pressures depending on different factors
  d. Governing pressure from three methods should bound uncertainties for design

9

Example 4
Issue #9: DC Seismic Design Basis Consideration

- **Current SRP 3.**
  a. SRP 3.7.2 does not address relation between CSDRS and generic site profiles.
- **Challenge**
  a. DC provides scope for assumed site based on 52.47 (a)(1)
  b. To ensure CSDRS be consistent with generic site profiles for assumed site in frequency content (frequency mismatch cannot appropriately propagate CSDRS into structural response in SSI analysis)
- **Proposed Enhancement**
  a. Incorporate guidance in SRP 3.7.2 to assess whether CSDRS is appropriate for these postulated site profiles in frequency content by demonstrating consistent frequency distributions between site profiles and CSDRS
- **Technical Basis**
  a. Consistent frequency distributions between site profiles and CSDRS to ensure appropriate propagation of CSDRS in structures through SSI.
  b. Clarify staff expectations for CSDRS and generic site profiles.

10

Conclusions

- Described need for guidance enhancement based on lessons learned in application reviews
- Described process for SRP 3.7/3.8 enhancements
- Identified issues addressed in next revision to SRP 3.7/3.8
- Discussed path forward to complete the SRP 3.7/3.8 revision
- Provided examples of how technical issues are addressed and basis
- Look forward to public workshop in April 2013

11

Questions ?

12